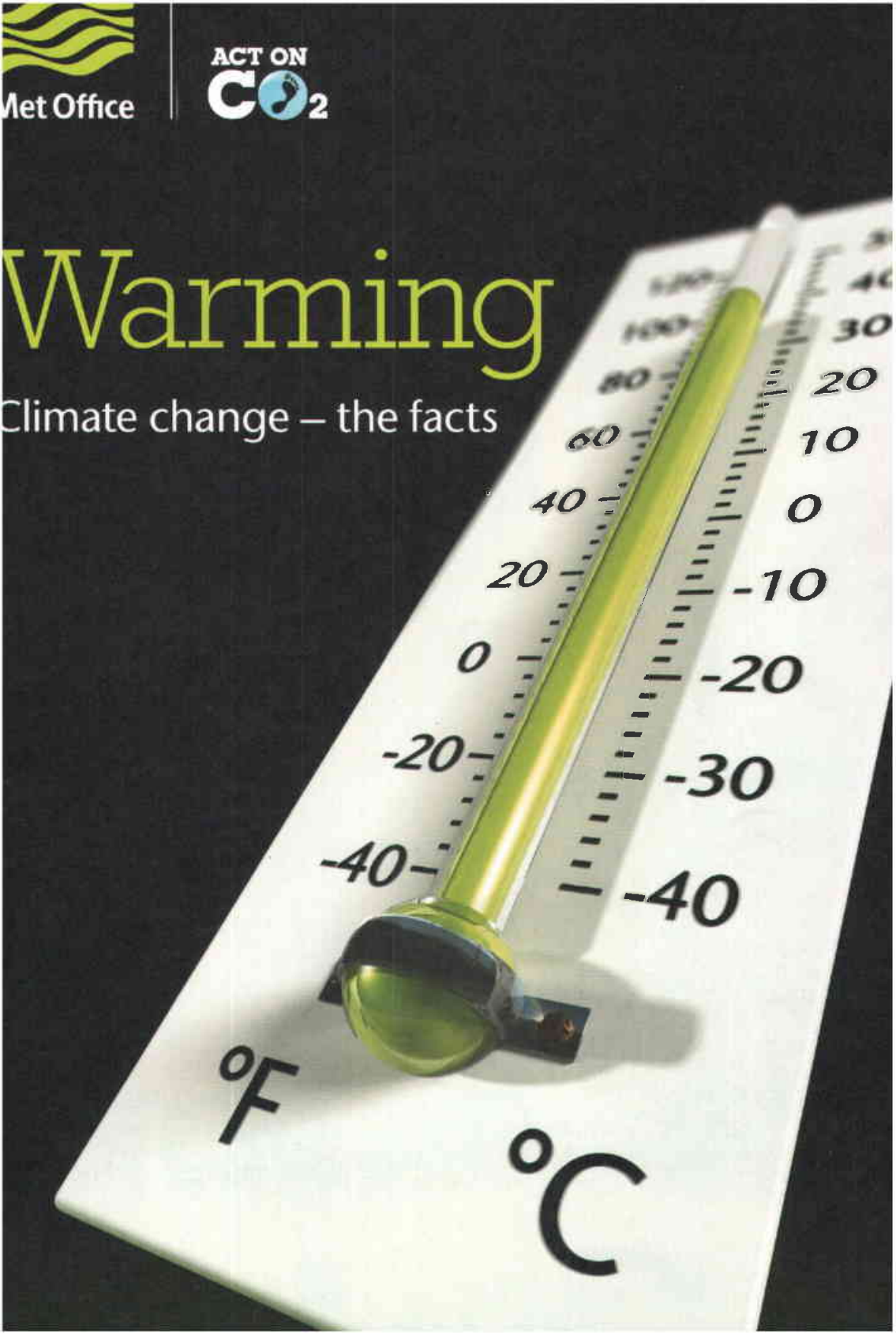
Met Office

ACT ON CO_2

Warming

Climate change – the facts



Climate change – your essential guide

limate change
a very real and
rgent global issue.
s consequences
re being
xperienced every
ay. We read about
in newspapers,
ear it debated
n Parliament and
ur children learn
bout it in school.

's a problem we
ll share, because
very single
ountry will be
ffected. Together,
oday, we must
ake action to adapt
o it and stop it —
r, at least, slow it
own.

It's now clear that man-made greenhouse gases are causing climate change. The rate of change began as significant, has become alarming and is simply unsustainable in the long-term.

This guide tells you everything you need to know about climate change and, importantly, what it means for you and what you can do about it.

It answers four questions:

- **What is climate change?**
- **What does it mean for the world?**
- **How can I be sure?**
- **What can I do now?**

We're causing it.
So let's do something about it

What is climate change?

The Earth's climate has changed many times in response to natural causes. The term climate change usually refers to man-made changes that have occurred since the early 1900s.

What is the difference between weather and climate?

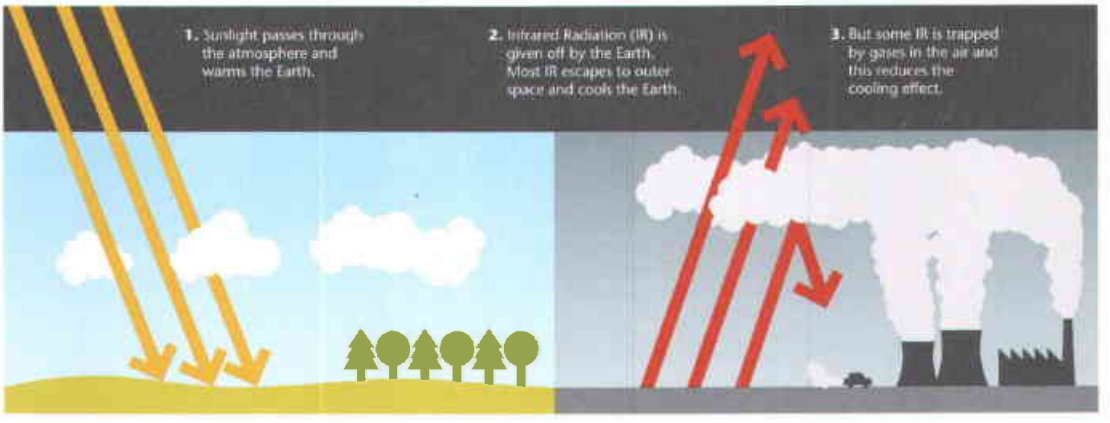
To understand climate change, it's important to recognise the difference between weather and climate. Weather is the temperature, precipitation (rain, hail, sleet and snow) and wind, which change hour by hour and day by day. Climate is the average weather and the nature of its variations that we experience over time.

What is the greenhouse effect?

The greenhouse effect is the natural process of the atmosphere letting in some of the energy we receive from the Sun (ultraviolet and visible light) and stopping it being transmitted back out into space (infrared radiation or heat). This makes the Earth warm enough for life.

For several thousands of years the atmosphere has been delicately balanced, with relatively stable levels of greenhouse gases. Human influence has now upset that balance and, as a result, we are seeing climate change.

Even if global temperatures rise by only 2 °C, 20-30% of species could face extinction.


1. Sunlight passes through the atmosphere and warms the Earth.
2. Infrared Radiation (IR) is given off by the Earth. Most IR escapes to outer space and cools the Earth.
3. But some IR is trapped by gases in the air and this reduces the cooling effect.

The greenhouse effect.

How are we causing climate change?

Human activities like burning coal, oil and gas have led to an increase in greenhouse gases in the atmosphere causing an enhanced greenhouse effect and extra warming. As a result, over the past century there has been an underlying increase in average temperatures which is continuing. Globally, the ten hottest years on record have all been since 1997.

What will happen if we don't reduce emissions?

If emissions continue to grow at present rates, CO_2 concentration in the atmosphere is likely to reach twice pre-industrial levels by around 2050. Unless we limit emissions, global temperature could rise as much as 7 °C above pre-industrial temperature by the end of the century and push many of the world's great ecosystems (such as coral reefs and rainforests) to irreversible decline.

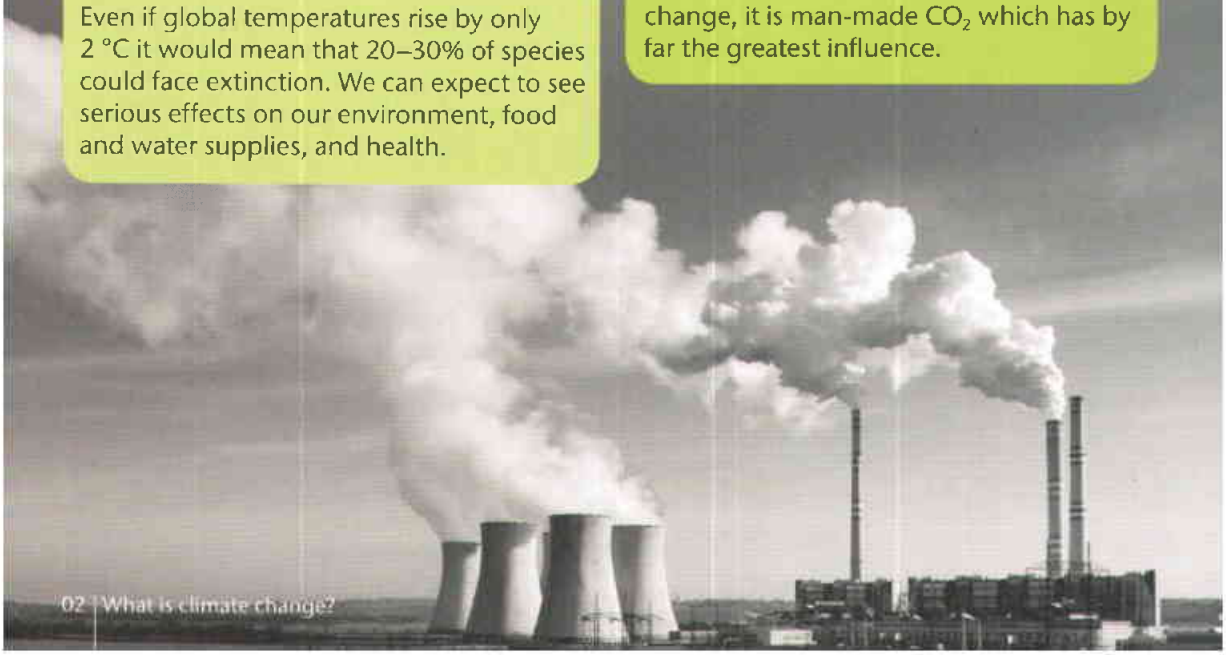
Even if global temperatures rise by only 2 °C it would mean that 20–30% of species could face extinction. We can expect to see serious effects on our environment, food and water supplies, and health.

Which gases are causing the most change?

The main greenhouse gas responsible for recent climate change is carbon dioxide (CO_2). This has been released in huge quantities by our modern way of life. Levels have also increased due to the destruction of rainforests, which play an important role in absorbing CO_2.

Human activities are increasing other greenhouse gases too, such as methane and nitrous oxide. Methane is produced by bacteria that live in places like landfill sites, peat bogs and in the guts of animals like cows and sheep. Nitrous oxide is increased by the use of nitrogen fertiliser in agriculture.

Both these gases have a powerful greenhouse effect and also contribute to climate change. However, they have not been released in such large quantities as CO_2 and methane does not last for as long in the atmosphere. So, while they make a significant contribution to climate change, it is man-made CO_2 which has by far the greatest influence.



Will it get hotter everywhere?

Yes. Even if the concentrations of greenhouse gases and aerosols stabilised at the year 2000 levels then we would still expect temperatures to reach 1.4 °C above pre-industrial levels by 2100 (Source: IPCC).

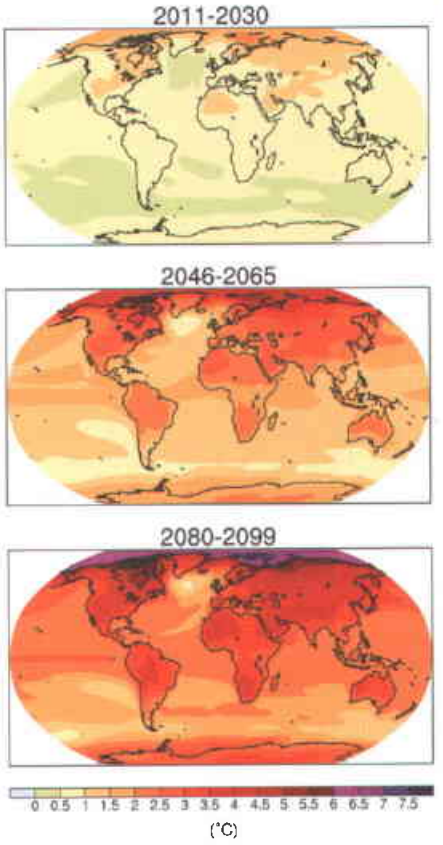
Even if emissions peak in 2015 and decrease rapidly at around 3% every year after that, there may only be a 50:50 chance of keeping global temperature rise below 2 °C.

Every delay of ten years in the peak emissions would add about 0.5 °C of warming.

Which areas are warming most?

In recent decades the Arctic has been heating twice as fast as the rest of the world, largely because Arctic ice, which reflects sunlight and keeps the surface cool, has decreased. In particular, summer Arctic sea-ice has decreased by about 10% per decade since 1979. Land-ice and snow-cover have also decreased — a bigger effect in the short-term because land heats up faster than the sea.

The Northern Hemisphere is warming more than the Southern Hemisphere. This is because the Northern Hemisphere has more land mass, which heats faster than water.



Map showing how the world will warm by the early, mid and late 21st century for a medium-high emissions scenario.

IPCC 2007

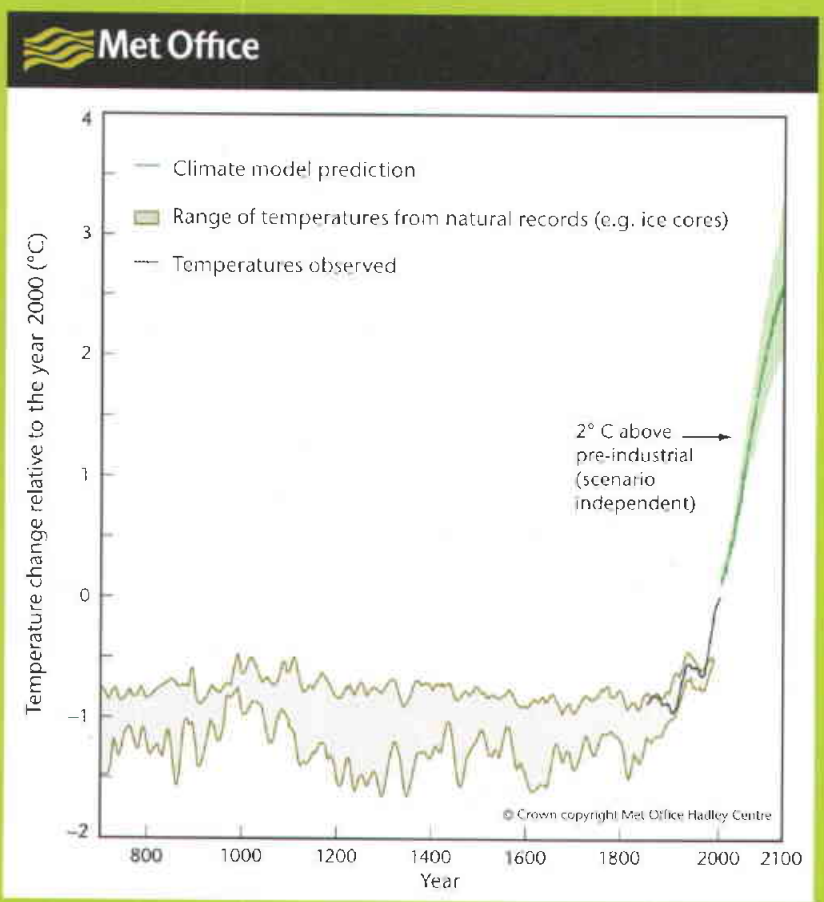
Why are sea levels rising?

A warming climate raises sea levels in two ways:

1. **Thermal expansion** — as water warms it expands, like liquid in a thermometer. A warming climate will heat the oceans, causing sea levels to rise.
2. **Ice-melt** — large amounts of water are locked in glaciers, permafrost and ice-caps around the world. Warmer weather is causing these to melt. Water from land-based ice will flow into the oceans, raising sea levels. Sea levels around the UK have already risen by 10 cm since 1900 and scientists are still researching how quickly they will continue to rise.

What does it mean for the world?

Climate change will mean warmer temperatures which will change rainfall patterns, cause snow and ice to melt and affect the intensity of extreme weather such as storms and heatwaves. We have already begun to experience some of these impacts and many other knock-on effects:



Past records and future projections (medium-high emissions scenario) of Earth's surface temperature change.

Water & Food

Health

Environment

Ecosystems

Our well-being will be threatened by more frequent and intense heatwaves, floods, storms, wildfires and droughts around the world.

Around 1.5 billion people currently live in water-stressed regions. Climate change and population growth could increase this to nearly 7 billion by the 2050s, intensifying competition for this life-giving resource. Some areas could become more fertile; others more barren. This may lead to regional food shortages, mass migration and poverty. Malnutrition is expected to increase in developing countries (Source: IPCC 2007).

Our well-being will be threatened by more frequent and intense heatwaves, floods, storms, wildfires and droughts. However, deaths from cold-related diseases will reduce. Patterns of disease will also change, with wide areas of the world at risk from major diseases, such as Dengue.

Coastal areas will experience more flooding from rising sea-levels, especially large river deltas which tend to be highly populated e.g. the Nile Delta. Meanwhile, some areas will attract more tourism as their climates alter.

Amazonia is already damaged by deforestation. Climate change may magnify this impact by increasing the risk of fire. Other precious areas of high biodiversity, such as those in South Africa, may see major losses of species as habitat conditions change. Around the world, some animals and plants may benefit and flourish in a changing climate, while others are likely to suffer.

What about the UK?

Even across relatively small areas like the UK, climate change is expected to cause marked regional differences in temperature and rainfall by the end of the 21st century.

How our climate has changed

- Central England temperatures have increased by 1 °C since the 1970s.
- Total summer rainfall has decreased in most parts of the UK.
- Sea-surface temperature around the UK has risen by about 0.7 °C over the past three decades.
- The UK has experienced nine of the 10 warmest years on record since 1990.
- Sea levels around the UK have risen 10 cm since 1900.

How our climate may change

- Under a medium emissions scenario, the annual average temperature rise by the end of the century is very likely to be more than 2 °C and less than 5 °C. The central estimate is 3.5 °C.
- Temperatures are expected to rise across the UK with more warming in summer than in winter. The summer average temperature rise in the South East is very likely to be above 2 °C and below 6.4 °C. The central estimate is 4 °C.
- The urban heat island effect already warms central London by more than 10 °C on some nights. Increased urbanisation and release of waste heat would increase this still further – on top of the effects of global warming.
- As summers become warmer and drier droughts are more likely, particularly in the South East. There may also be more intense downpours of summer rainfall, which could lead to flash flooding.
- The extreme heatwave of 2003, when average summer temperatures were 2 °C higher than normal, led to more than 2,000 additional deaths in the UK. Such hot summers could happen every other year by the 2040s.
- Heavier winter precipitation is expected to become more frequent, potentially causing more flooding.
- Sea-level across the UK is projected to rise between 11 and 76 cm by the end of the century. In the worst case, rises of up to 1.9 m are possible but highly unlikely.

How we'll need to adapt

Many aspects of our lives and lifestyles will be affected by climate change.

We can adapt to reduce the impact of many, but not all, of these changes.

		Energy	Water
Extreme weather		The UK's energy infrastructure is at risk from extreme weather, such as flooding and heatwaves.	Wetter winters, and storm surges combined with sea-level rise, will increase flood risk in the UK.
High temperatures		Hotter UK summers will increase the demand for air conditioning; less heating will be needed in winter. Power cables under perform when it is hot.	Higher temperatures could cause water demand to rise.
Drought		Many power stations use water from rivers to cool their turbines — less water will be available, increasing competition with other water users.	Droughts will increase current pressure on water demand, supply and quality — including in the UK.
Floods		In the UK, many power stations are situated on the coast, so future planning will need to account for predicted sea-level rise.	Sewage flooding could increase due to more heavy rainfall.
Urban heat island		Cities tend to be much warmer than their surroundings. Peaks in electricity demand due to air conditioning occur during summer heatwaves.	Higher urban temperatures will increase water consumption, including demand associated with cooling buildings and watering gardens & parks.

Agriculture	Built environment	Transport
Extreme weather, such as storms or heatwaves, can cause major damage to crop yields.	Buildings in the UK will have to withstand more extreme weather – increased temperatures and rain.	Increased temperatures and rain will have a big effect on road and rail networks in the UK.
Higher year-round temperatures could allow new crops to flourish in the UK. Diseases and pests could survive milder UK winters.	People will be more vulnerable to heat stress caused by increased temperatures and humidity.	Road surfacing will melt unless replaced with different materials.
Droughts could reduce UK crop yield and increase demand for irrigation. Many UK potato varieties are not drought tolerant.	Drier soils lead to subsidence – foundations may have to be very deep to reach more secure soil.	Subsidence caused by changes in soil-moisture content may lead to more frequent and expensive repair of infrastructure.
More heavy rain will lead to increased risk of flooding. This will wash out nutrients and lead to waterlogging of fields.	The location of building projects, drainage and flood resilient construction will be increasingly important in the UK.	Coastal roads and railways are threatened with wetter UK winters, intense rainfall, coastal erosion and sea-level rise.
Higher winter temperatures in cities can support the life cycle of some non-native agricultural pests which can spread into rural areas.	Reflective roof coverings and light-coloured building materials can help combat over-heating in cities.	Summer temperatures, which can already reach uncomfortable levels on public transport systems in UK cities, are set to increase.

How can I be sure?

sn't the climate always changing?

es. There is natural variability in the Earth's limate but the current climate change is ery unusual as it's not exclusively part of a atural cycle.

Natural factors include volcanic eruptions, erosols and phenomena such as El Niño and a Niña (which cause warming and cooling f the Pacific Ocean surface).

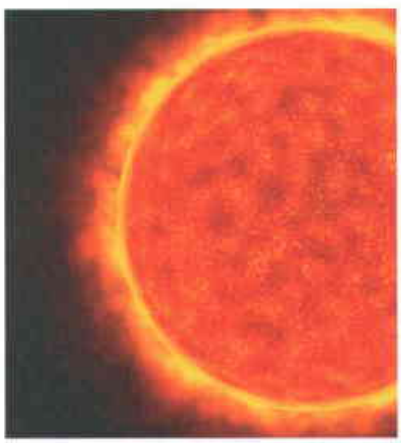
Natural climate variations can lead to periods vith little or no warming, both globally and egionally, and other periods with very rapid varming. However, there is an underlying rend of warming that is almost certainly aused by man's activities.

Natural variability will continue to bring warm and cool years but, because of climate change, the warm years will be warmer and more frequent.

Aren't all these changes down to the Sun and natural factors?

No. Many factors contribute to climate change. Only when all the factors are considered can we explain the size and patterns of climate change over the last century.

Although some people claim that the Sun and cosmic rays are responsible for climate change, measured solar activity shows no significant change in the last few decades, while global temperatures have increased significantly. Since the Industrial Revolution, additional greenhouse gases have had about ten times the effect on climate as changes in the Sun's output.



Much of the relatively small climate variability over the last 1,000 years, but before industrialisation, can be explained by changes in solar output and occasional cooling due to major volcanic eruptions.

Since industrialisation, CO_2 has increased significantly. We now know that man-made CO_2 is the likely cause of most of the warming over the last fifty years.

Do climate scientists really agree about climate change?

Yes. The overwhelming majority of climate scientists agree on the fundamentals of climate change — that climate change is happening and has recently been caused by increased greenhouse gases from human activities.

The core climate science from the Intergovernmental Panel on Climate Change (IPCC) was written by 152 scientists from more than 30 countries and reviewed by more than 600 experts. It concluded that most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in man-made greenhouse gas concentrations.

The overwhelming majority of climate scientists agree on the fundamentals of climate change.

Are computer models reliable?

Yes. Computer models are an essential tool in understanding how the climate will respond to changes in greenhouse gas concentrations, and other external effects, such as solar output and volcanoes.

Computer models are the only reliable way to predict changes in climate. Their reliability is tested by seeing if they are able to reproduce the past climate, which gives scientists confidence that they can also predict the future.

But computer models cannot predict the future exactly. They depend, for example, on assumptions made about the levels of future greenhouse gas emissions.

Even if all CO_2 emissions stopped today, we will need to adapt to some climate change.

change.

Are you sure there's a link between temperature rise and CO_2?

Yes. Temperature and CO_2 are linked. Studies of polar-ice layers show that in the past, rises in temperature have been followed by an increase in CO_2. Now, it is a rise in CO_2 that is causing the temperature to rise.

Concentrations of CO_2 have increased by more than 35% since industrialisation began, and they are now at their highest for at least 800,000 years.

When natural factors alone are considered, computer models do not reproduce the climate warming we have observed. Only when man-made greenhouse gases are included do they accurately recreate what has happened in the real world.

Isn't the recent warming due to the growth of our towns and cities?

No. The climate is warming everywhere because of CO_2 emissions. Temperatures in cities are unnaturally high because of the warmth from heating homes and offices, heavy traffic, high concentrations of people and heat stored in buildings and concrete.

Our observations come from urban and rural areas on land and from the sea, which covers 70% of the Earth.

We manage data from cities carefully to ensure they do not skew our understanding of climate change.

Concentrations of CO_2 have increased by more than 35% since industrialisation began

The 10 warmest years on record have occurred since 1997

(as of July 2009).

How does El Niño affect our climate?

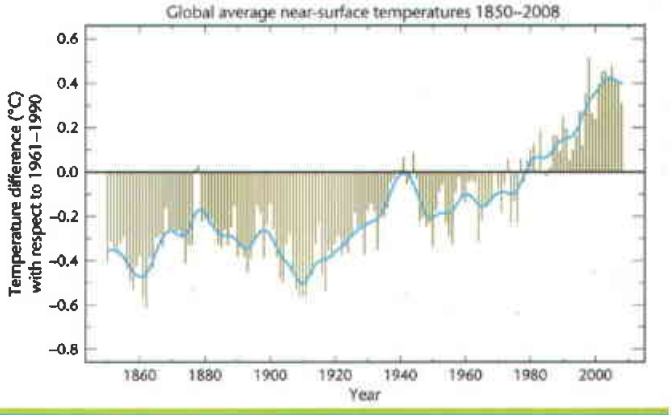
El Niños are natural variations in climate. When there is an El Niño, the tropical eastern Pacific is warmer than average and global temperatures are also warmer. A particularly strong El Niño occurred in 1998 — the warmest year on record across the globe.

The opposite effect is La Niña. When La Niña occurs, it's cold in the eastern Pacific resulting in cooler than average temperatures. 2007 and 2008 saw a long-lasting La Niña, but 2008 was still the tenth warmest in the global record.

Has global warming now stopped?

No. The rise in global surface temperature has averaged more than 0.15 °C per decade since the mid-1970s. The 10 warmest years on record have occurred since 1997. Global warming does not mean that each year will necessarily be warmer than the last because of natural variability, but the long-term trend is for rising temperatures. The warmth of the last half century is unprecedented in at least the previous 1,300 years.

Met Office



Global average temperature for each year (green bars) with temperature trend (blue line).

What can I do now?

What is being done to tackle the problem?

Internationally, countries are negotiating a global agreement through the United Nations. The agreement aims to avoid dangerous climate change, set ambitious emission reduction targets, and encourage low carbon development — particularly supporting the poorest countries. These negotiations are due to be concluded at a vital meeting in Copenhagen in December 2009.

At the same time, many governments all over the world are putting in place policies that aim to reduce emissions in their own countries. These policies include measures to increase energy efficiency in homes and businesses, and increase the use of renewable energy sources and more sustainable forms of transport. They are also working towards other adaptations necessary to cope with the changes in climate already happening.

What's the rush?

Urgent steps need to be taken to tackle climate change. The earlier action is taken, the more effective it will be. If we want to hand on this world to our children in a fit state, we must do something about our emissions and climate change.

How can I help?

Over 40% of current CO_2 emissions are caused by the choices we make as individuals. Simple actions can save money and energy; and there are many things you can do to reduce your CO_2 emissions, from switching off electrical appliances when they are not being used to insulating your home properly and walking instead of driving one short trip a week. To find out more ways you can reduce your carbon footprint and save money, visit the ACT ON CO_2 website.

People in organisations everywhere can also take steps to adapt now to the climate change we are experiencing, and will continue to experience over the coming decades. Visit the Defra and Met Office websites for more information and ways to adapt to climate change.

Every action we take to reduce greenhouse gases will make a difference.

Links

Met Office

Our web-based Climate Change Centre can help you understand the facts, the science and the impacts of climate change. It also looks at what can be done to adapt to the inevitable changes.

www.metoffice.gov.uk/climatechange

ACT ON CO_2

ACT ON CO_2 is a government-led initiative to encourage and help people to reduce their CO_2 emissions.

www.direct.gov.uk/actonco2

DECC

The Department of Energy and Climate Change (DECC) is responsible for all aspects of UK energy policy, and for tackling global climate change.

www.decc.gov.uk

Defra

The Department for Environment, Food and Rural Affairs (Defra) is responsible for helping the country adapt to inevitable climate change.

It has funded the latest Met Office climate projections for the UK. See www.ukcip.org.uk for more.

www.defra.gov.uk

Mixed Sou
Product group from
forests, controlled s
recycled wood or fib
www.fsc.org Cert n